Module 17
Electromagnetic Waves and Wireless Communication

What this module is about

Are you familiar with the saying that goes –*"The world is becoming smaller."?* What does this statement imply? Does it mean that the world's size is indeed decreasing?

People around the world are now able to communicate with one another through innovations in technology. Cell phones are very familiar to youngsters like you. You can talk to your friend in another country using this small gadget and you feel like she/he is just around the corner. Cell phones along with other telecommunication devices have made distance immaterial. Wireless communication has made the world smaller!

What does wireless communication mean? How is it developed? This module will introduce you to the advancement of wireless communication and the physics principles behind it. So hang on and have fun learning the following lessons:

- **Lesson 1 – Electromagnetic Waves**
- **Lesson 2 – Wireless Communications**

What you are expected to learn

After going through the module, you will be able to:

1. trace the development of wireless communication;
2. explain how electromagnetic waves are produced;
3. discuss the properties and uses of the different regions of electromagnetic spectrum;
4. describe how radio signals are generated, transmitted and received;
5. explain how radio communication devices like cell phones, radio and TV work;
6. discuss how lasers and fiber optics have improved telecommunication;
7. realize the importance of developments in electronic technology in the transmission of information and,
8. recognize the effect of the information superhighway on the affairs of daily living.

It's good to achieve all these objectives! Here are a few tips to make your learning experience even better!

How to learn from this module

1. Read the module carefully. You may use references along with this module. Suggested references are listed on the last page.

2. Follow instructions diligently.

3. Answer the pretest. The pretest is composed of questions that will determine how much you know about the topic. It is given before you start with the lesson proper. Accomplish it honestly. Answer key is provided at the end of the module. Please try not to look at it while answering. You can check your answers once you are finished.

4. Activities and/or exercises are given to deepen your understanding of the concept and to develop your skills. Take time in doing these.

5. Take note of important ideas and points for clarification.

6. Don't forget to answer the posttest and see how much you have learned. You may go back to lesson discussions or consult references if your answers are incorrect

What to do before (Pretest)

I. Multiple Choice

Direction: Write the letter of the best answer on the space provided before the number.

_____1. Electromagnetic waves are produced by _____
- A. currents
- B. voltage source
- C. any disturbance
- D. vibrating charge

_____2. Which of the following forms of electromagnetic waves is used mostly in communication?
- A. X-ray
- B. Infrared
- C. Radio wave
- D. Gamma rays

_____3. In the electromagnetic wave, the direction of the propagation of the wave is _____
- A. always to the right.
- B. cannot be determined.
- C. parallel to electric and magnetic field directions.
- D. perpendicular to the electric and magnetic field directions.

_____4. Which of the following forms of electromagnetic waves has the widest frequency range?
- A. x-ray
- B. microwave
- C. ultraviolet
- D. radio waves

_____5. What happens to the frequency of the electromagnetic wave if its wavelength increases?

A. decreases
B. increases as well
C. remains the same
D. can not tell; frequency and wavelength are two different concepts.

II. Discussing and Explaining

Direction: Answer the following questions briefly. Write your answer on the space provided.

1. How does your AM/FM radio pick up signal from the air?

2. List down communication devices that people are using at present and write down the benefits that each renders.

3. How does communication develop into wireless communication?

III. Sequencing

Some events and discoveries related to the development of communication are listed below. Number each one according to the correct order of occurrence from the earliest to the latest.

_____ invention of telegraph

_____ invention of telephone

_____ radio communication

_____ digital communication

Key to answers on page 26

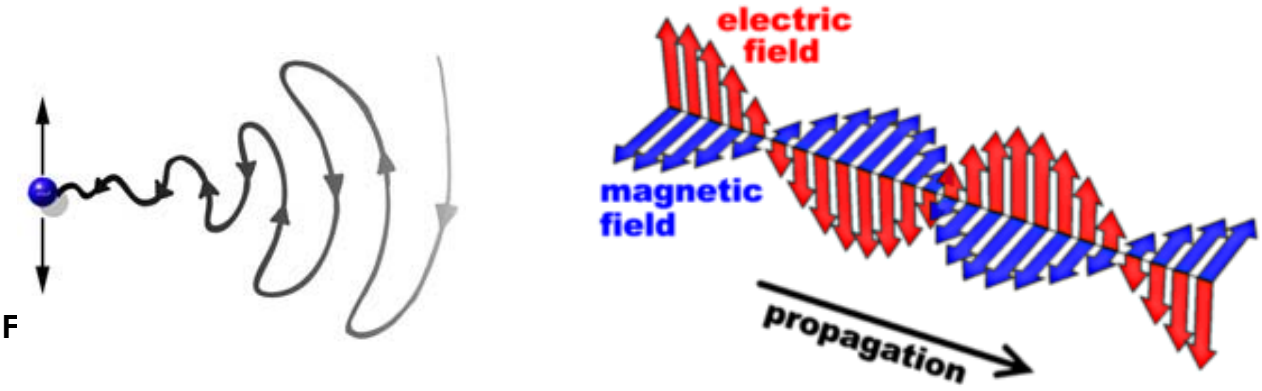
How was your performance in the pretest? At any rate, knowing what you know and what you don't know is a good starting point. Now let's move on!

Lesson 1 Electromagnetic Waves

Fundamental to studying wireless communication is knowing what electromagnetic waves are and how they are produced and used in communication. What exactly is electromagnetic wave? Is it the same as the mechanical wave that you learned previously? Basically, yes. How?

Production of Electromagnetic Waves

In your study of wave motion, a disturbance produces waves that can be transmitted through a medium. Electromagnetic waves are also produced by a disturbance caused by vibrating charge. When the charge is moved, the electric field around it is changed. Recall the Oersted's discovery: *A changing electric field produces a magnetic field*. A changing magnetic field is therefore produced around the vibrating charge. Furthermore, this changing magnetic field in turn produces electric field. Do you remember the Faraday's Law? And the cycle goes on. The changing magnetic and electric fields are perpendicular to each other and to their direction of propagation. They are therefore considered as transverse waves.



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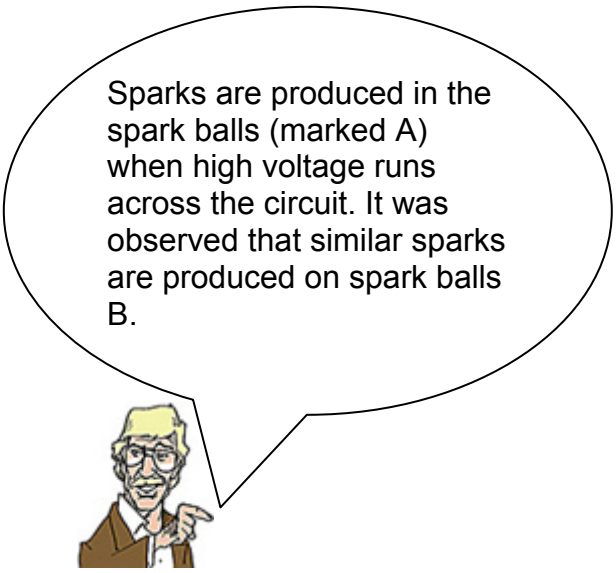
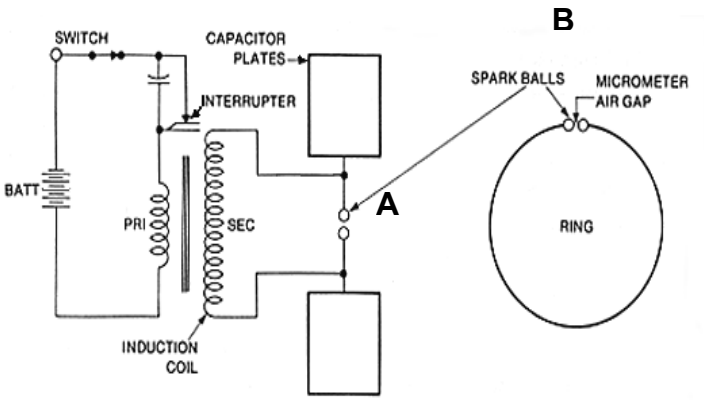
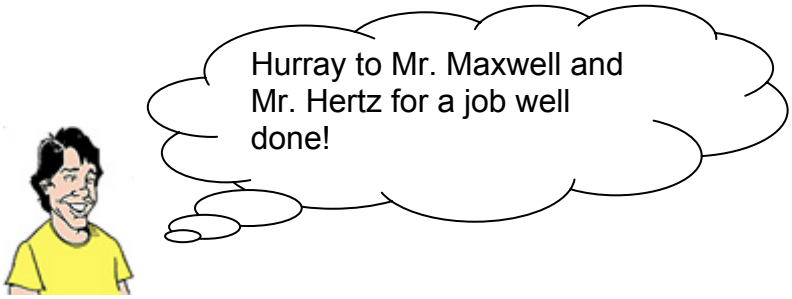
James Clerk Maxwell theorized that this mutual generation and propagation of electric field and magnetic field can be conceived as a form of moving energy carried by what he called as electromagnetic wave. So, if this is just like any wave, does it mean that it travels through a medium? No. Electromagnetic wave traverses empty space! However, Maxwell did not believe that electromagnetic wave propagate in space under any condition. He supposed that it must move at a certain speed. He calculated the speed of the wave based on Faraday's theoretical assumptions and experiments and concluded that the speed is 3×10^8 m/s – the same as the speed of light! He therefore proposed that *light is a form of electromagnetic wave*. Unfortunately, at that time, no experiment was done to verify his accounts. But after Faraday's death, Heinrich Hertz designed an experimental set-up that enabled him to generate and detect electromagnetic waves. Here's how he did it.



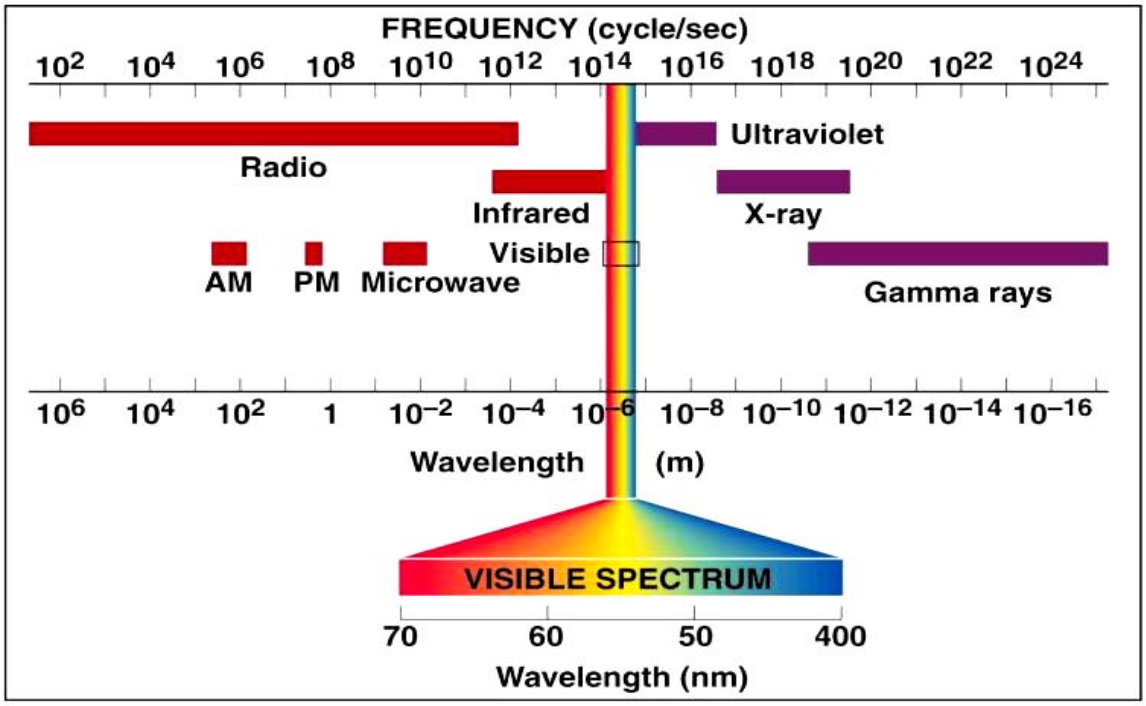


No wires were connected A to B but the same phenomenon was seen in the two gaps. Hertz concluded that vibrating charge, made evident by the sparks, produced EM waves that were detected by the set-up B. Hertz' experiment proved that electromagnetic waves do exist!

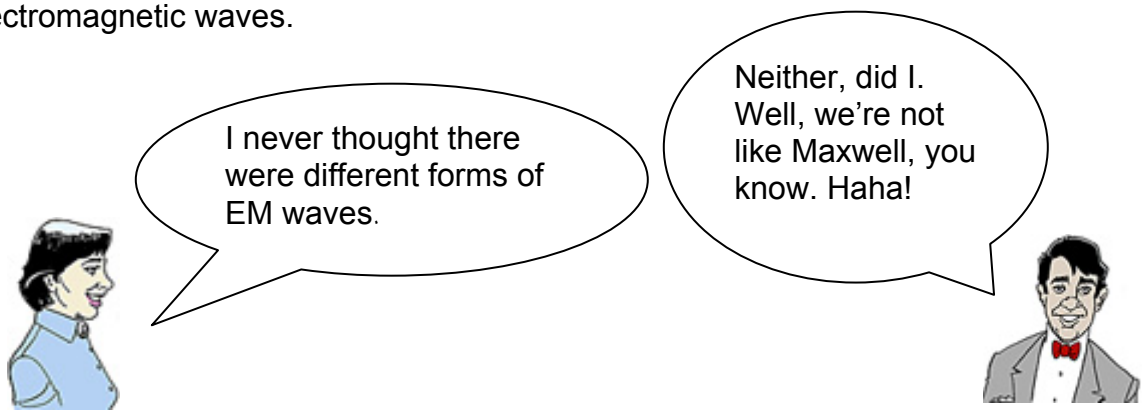


Electromagnetic Spectrum

In the previous discussion, you learned that light is a form of electromagnetic wave. Are there any other forms of this wave? Maxwell predicted that electromagnetic waves take several forms depending on their frequencies and wavelengths.



Electromagnetic waves extend from radio waves to gamma rays. In between these extreme values are microwave, infrared, visible light, ultraviolet and x-ray regions. The electromagnetic spectrum is the wavelength and frequency chart of these forms of electromagnetic waves.



What you will do

Activity 1.1, Activity 1.2

Activity 1.1 Look at the electromagnetic spectrum more closely this time. What do you notice? Are the divisions of the regions distinct? Write your answer on the spaces provided. Answers may be checked against next page's discussion.

_____
_____
_____
_____
_____
_____
_____

Activity 1.2
Using the same spectrum, determine the frequency and wavelength ranges of each of the forms of electromagnetic waves. Enter your data on the table.

EM Wave	Frequency Range (hertz)	Wavelength Range (meters)
Radio Waves	_____	_____
Microwaves	_____	_____
Infrared	_____	_____
Visible Light	_____	_____
Ultraviolet	_____	_____
X-rays	_____	_____
Gamma rays	_____	_____

Key to answers on page 27

Some of the regions in the electromagnetic spectrum overlap. Can you identify these regions? The waves are therefore not classified based on the wavelength values but on their sources. The table below lists the sources and some of the uses/applications of the different forms of electromagnetic waves.

Forms of Electromagnetic Wave	Source	Uses/Applications
Radio waves	Vibrating electrons 	Wireless communication
Microwaves	Vibrating electrons 	Communication particularly long distance radio relay systems, microwave ovens
Infrared	Hot objects 	Missile guidance, long distance photography, medical treatment, burglar alarms
Visible Light	Very hot objects 	Vision
Ultraviolet	Arcs and gas discharges 	Medical treatments, sanitation process
X-rays	Electrons striking a target	Medical purposes, security
Gamma Rays	Nuclei of radioactive atoms	Cancer treatment, metal defect detection, beneficial mutations, food preservation

Both the microwave and radio waves come from vibrating electrons. What then distinguishes the two? Try to look at the electromagnetic spectrum and compare the frequency range of microwave and radio wave. Which has greater frequency range?

What you will do

Self-Test 1.1

Congratulations! You finished the first lesson on Electromagnetic Waves! This time, synthesize all the concepts and principles you learned in the lesson. These questions will serve as your guide:

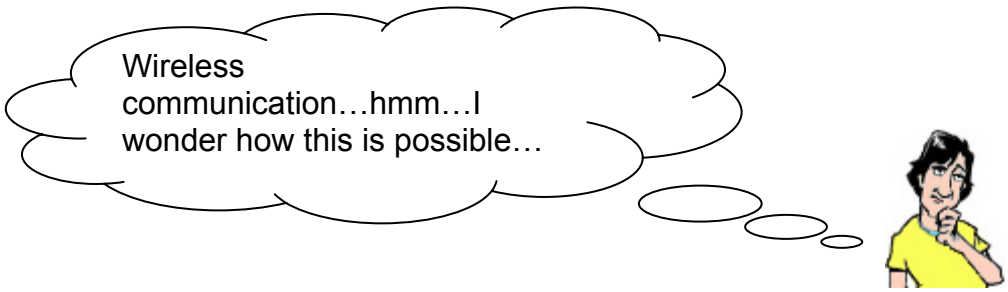
1. How do you explain electromagnetic wave as a consequence of the principles of electromagnetism?
2. Compare and contrast the different forms of electromagnetic waves in terms of their properties and uses.
3. What form of electromagnetic wave is widely used for wireless communication?

Write your answer on the spaces below.

Key to answers on page 27

Lesson 2 Wireless Communication

You have learned that electromagnetic wave is applied in wireless communications among others. In the succeeding discussions, you will venture into how this wave is used in sending information and messages and how wireless communication has affected people's daily affairs.



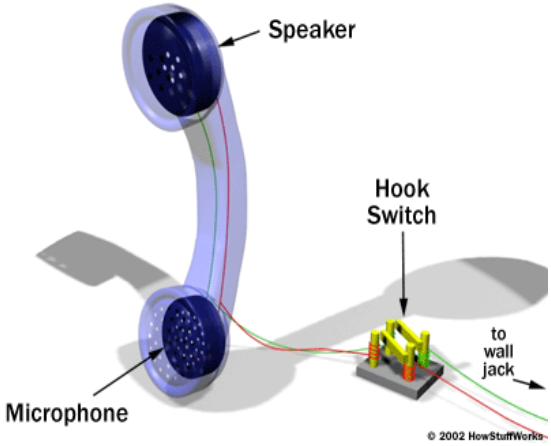
Development of Communication

Before wireless communication came into existence, a number of means of communication have already been developed. The first of these is sending messages through electricity by Charles Morrison. Wires are charged one after the other and pieces of papers at the receiver end are attracted. The attracted paper determines the letter being transmitted. However, such method of communication is applicable to short distances only. Later, Samuel F. B. Morse invented the telegraph, which uses electromagnet. Can you recall what electromagnet is and how it works? Figure 5 illustrates how the telegraph works.

When the sender taps the key, circuit is closed and electric current is delivered to the sounder. The sounder operates by giving distinct sounds (like clicks) or a paper is tapped and the message is received. Message has to be decoded for it to be understood.

Fig. 5. Telegraph

In 1876**,** Alexander Graham Bell experimented on telegraph and found means to eliminate coding and decoding of messages. He developed the telephone that allowed sounds to be transmitted over the wires. Figure 6 that shows how this is done.



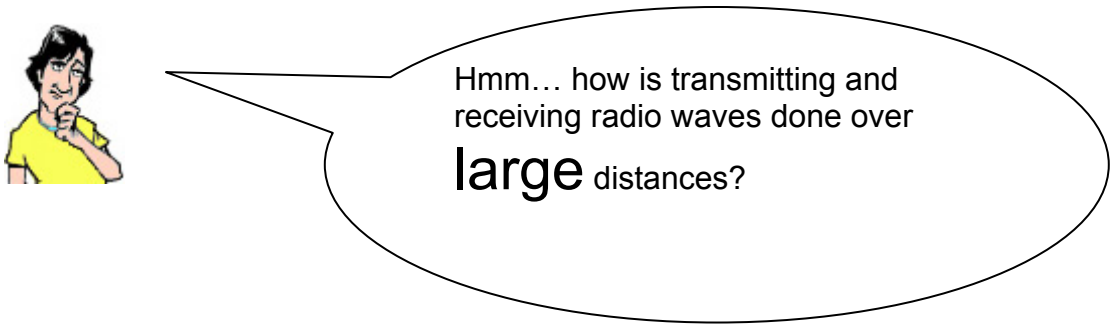
Carbon granules are in the microphone and are connected to the telephone circuit. When one speaks on the microphone, the sound waves of the voice compress and decompress the granules resulting to *changing of the resistance in the wire*-a pattern of variation. When the current reaches the receiving station, the speaker, on the other hand, converts this electrical energy back to sound energy with the corresponding sound pattern.

Fig. 6. Telephone

You might say that this is quite a breakthrough. Yes, indeed! But here's more. Wires are no longer used in most of today's communication. Remember the cell phones? Communication now is "wireless". There is no need to connect the transmitting and receiving stations. Energy is transmitted through space! Now, isn't this a huge discovery? And we look forward to some more, don't we?

Radio Communication

Today, conversations, data and even music can be transmitted through air over millions of kilometers because of *radio waves*. Wireless communication has become possible through transmission and reception of these radio waves. *Remember, radio waves can be transmitted through empty space!*



Let's discuss the transmission and reception of radio waves one at a time. Let's start with how radio waves are transmitted. Simple radio transmitters work on two basic processes: *(1) transformation of sound energy to electrical energy; (2) transformation of electrical energy to electromagnetic energy*; and on three simple components: (1) microphone circuit; (2) oscillator circuit and (3) antenna. Now, let's discuss how the two processes occur in these 3 basic components.

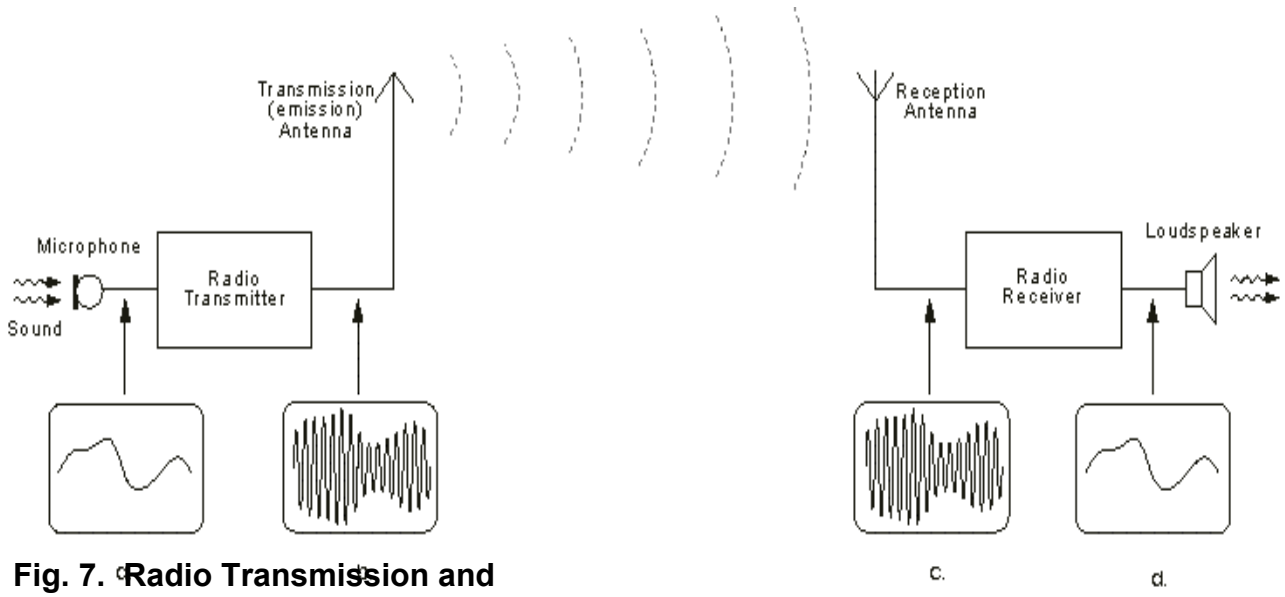
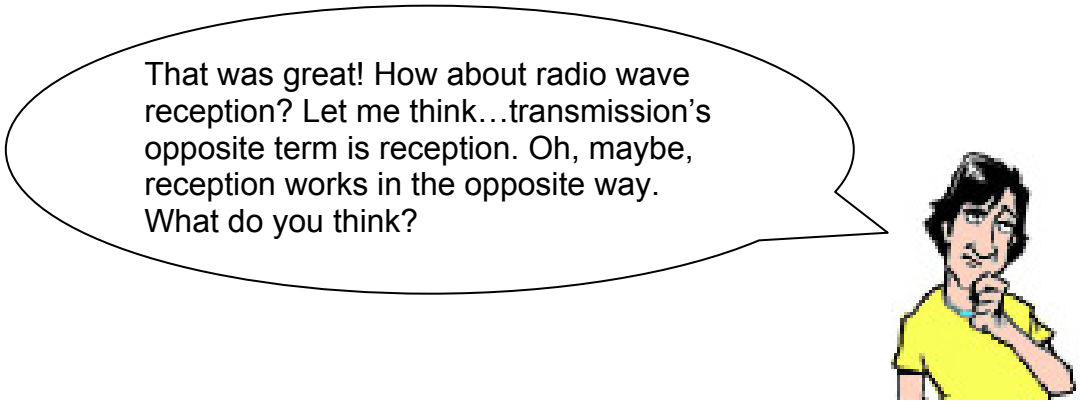


Fig. 7. Radio Transmission and Reception

Move the diaphragm to allow the wire coiled very loosely around a permanent magnet to vibrate. As it vibrates, this wire gains a changing magnetic field and induces current in the adjacent wire. The first transformation is finished. Next, the adjacent wire is connected to the oscillator circuit where the charges are made to oscillate. This implies that electric field varies. What happens if electric field is changing? Magnetic field builds up, therefore, antenna rods are surrounded by alternating electric and magnetic fields propagating right angles with each other and with their direction of motion-the radio wave! This is the second transformation.



Radio waves reception is the complete reverse of radio transmission. That is, first, electromagnetic wave is transformed to electrical energy and then to sound energy. How? When the electromagnetic wave in the form of radio wave passes by a receiving antenna, energy is absorbed and current in the conductor induces a potential difference. This voltage

is delivered to the receiver where it is amplified. This varying electric field produces changing magnetic field that causes vibrations in the radio speakers!

What you will do

Activity 2.1 Make your own radio transmitter

Materials:
9-volt battery (new)
coin
AM radio

Procedure:

1. Take the new battery and coin.
2. Bring the AM radio near you and tune it to the area where you hear a static.
3. Repeatedly tap the two terminals of the battery with a coin.
4. Describe the sounds produced.

Key to answers on page 27

Now, I understand why wires are no longer used in connecting transmitting and receiving stations. But, I still have one question in mind.

How are sounds, messages, information carried by this radio wave?

It is important to note that the radio waves being transmitted and received cannot carry information, messages and sounds unless it is *modulated*. Modulation of the wave is a way to encode these data. To modulate, patterns of variations called signal must be produced containing all the information that one wishes to send and this signal is overlaid onto the radio wave. The following illustration shows this.

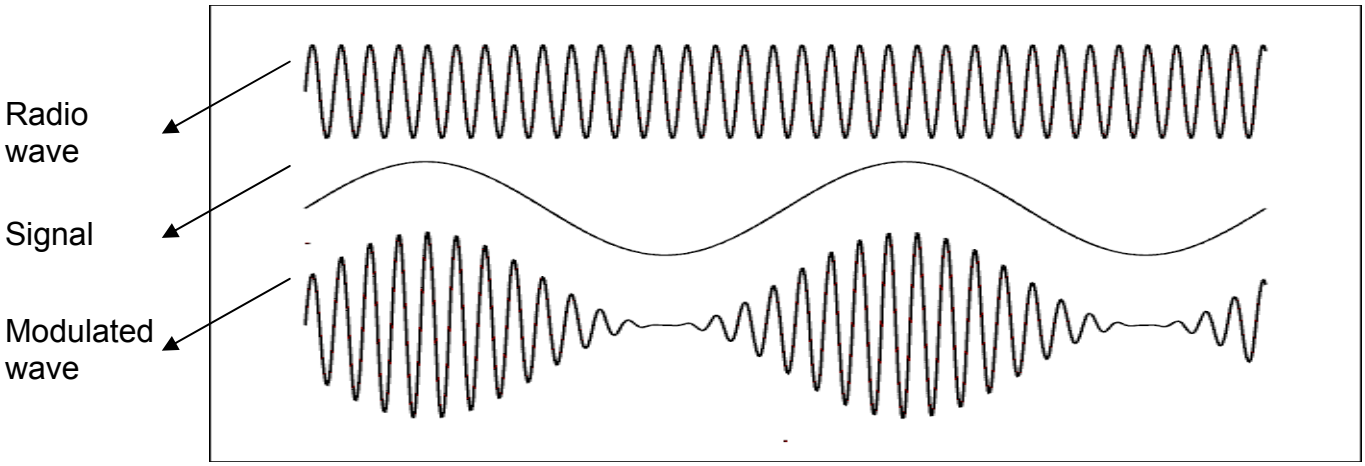


Fig. 8. Modulated wave

We have three ways of encoding information:

1. **Pulse Modulation (PM)**

   This is done by simply turning the wave on and off. It is not a very common modulation but it still is being used by United States for radio controlled clocks.

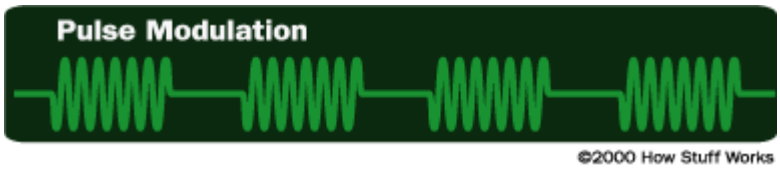


Fig. 9

2. **Amplitude Modulation (AM)**

   This modulation involves changing the amplitude of the wave but keeping its frequency constant. AM is used in standard broadcasting. AM stations and the visual aspect of the TV signal use amplitude modulation. The transmissions produced, however, are easily affected by static and other interferences.

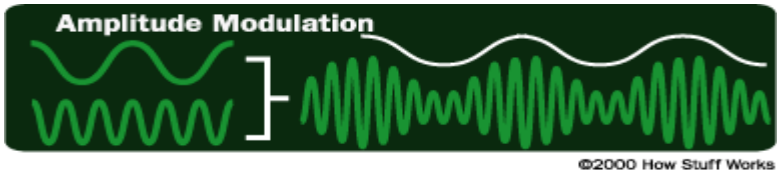
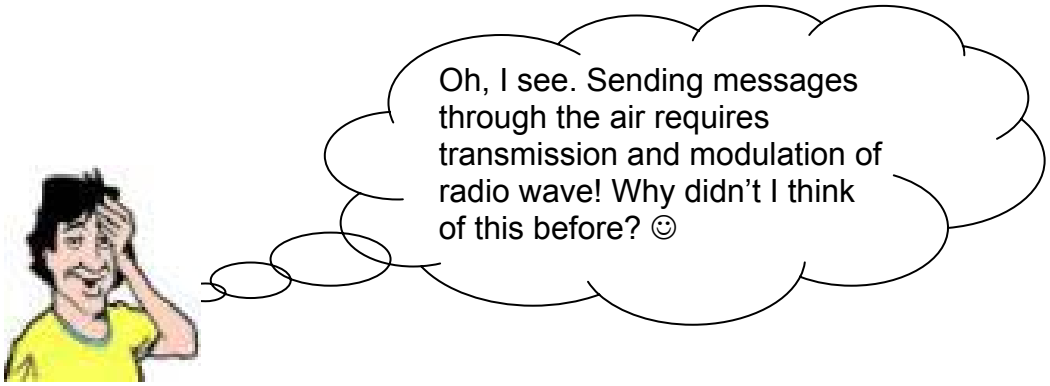


Fig. 10

3. Frequency Modulation FM)

Here, the radio wave's amplitude is kept constant while the frequency is changed. This kind of modulation is not easily affected by static and interference. It is widely used in FM stations, sound portion of the TV signal, cordless phones and cell phones.

Fig. 11



Did you know that…

Frequency is an important characteristic of the radio wave. AM broadcast frequency is about 1,000, 0000 cycles per second (hertz). For example, when you tune in to your favorite AM radio station at 630 on the dial, the radio is tuning to the radio wave with the frequency of 630,000 cycles per second! On the other hand, FM radio operates on 100,000,000 cycles per second. So when you turn to 101.1 YES FM, your radio is tuning to 101, 100,000 cycles per second frequency.

What is your favorite FM station? What frequency does your radio tune to when you dial this station?

Different radio and television stations use different frequencies in broadcasting. Broadcast bands are indicated in the radio and television sets. Here is something for you to discover:

What you will do

Activity 2.2 Broadcast Bands

You will need:
FM/AM radio
Television Set

Take your FM/AM radio unit and look for the different broadcast bands. Do the same with your television set. Enter what you have found in the table and research the frequency range and uses for each band. Also, provide appropriate title for the table.

Type of Broadcast Band	Frequency Range	Typical Uses

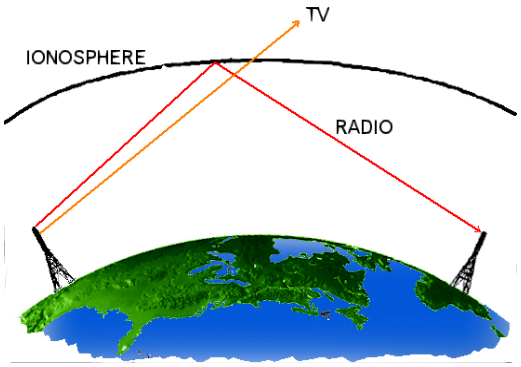
Key to answers on page 28

Satellite Communication

We know for a fact that radio waves travel in straight line. Why then are we able to receive messages/information from other parts of the world?

First, let's take a short review of some facts we learned in earth science. One layer of the atmosphere is composed of ionized gases. This layer is called ionosphere. When radio waves are sent into the air and strike the ionosphere, the low frequency ones are reflected back to earth. However, the high frequency waves penetrate into the ionosphere and to the space. Therefore, *communication satellites are used to reflect these waves back to earth which are then captured by the receiving antennas*. Most communication satellites are used for telephone services while the rest are for television broadcasting, scientific research and weather forecast.

Fig. 12.
Penetration of high frequency waves into the ionosphere



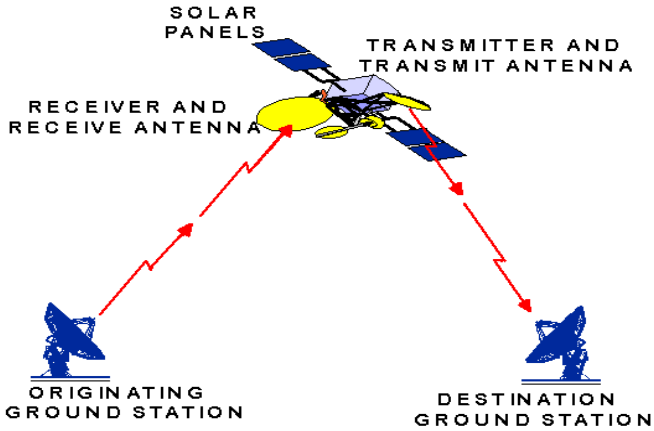
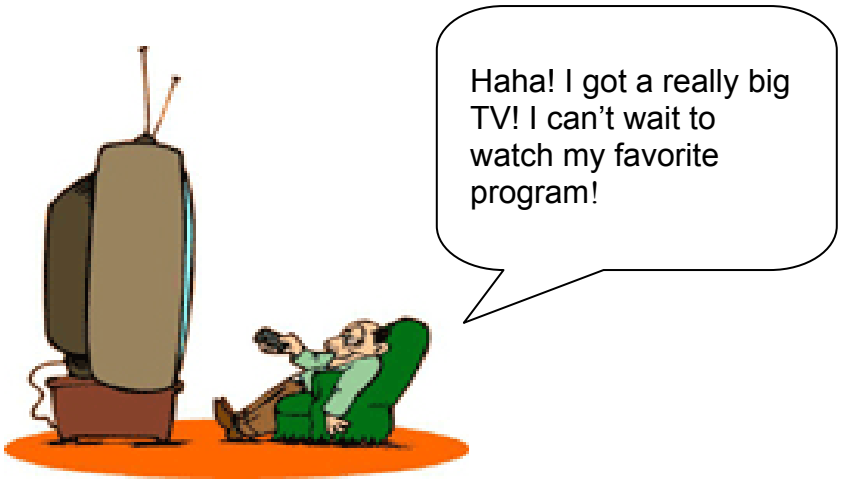


Fig. 13
Reflection of High Frequency Waves by Satellite

Communication Devices

Most households today have television sets. People use this communication device to receive news, entertainment and other information. There are many different ways for the TV to receive signals. The most common (which is also the focus of this discussion) is the broadcast programming received through the antenna (e.g. analog TV). How does this

normal broadcast signal get into the television set? The picture aspect of TV signal requires 4 megahertz of bandwidth. A *bandwidth* is a frequency range given to a channel. It is some sort of electrical “space” taken by the channel on a cable. Now when sound called vestigial band and little buffer space are added, a typical TV signal requires 6 megahertz of bandwidth. So the radio spectrum is chopped into 6 megahertz bandwidths and these correspond to the different channels we tune into. When the TV is tuned into the favorite channel, the TV extracts the video signal and the sound signal of this particular frequency band.



Not only do people use TV for information, they also use cell phones for communication especially for the Asians and Europeans. *Cell phone is a very sophisticated radio, but still a radio nonetheless*. It is today’s answer to the emerging demand for mobile communication. Before the cell phone was invented, people installed radio-telephones in their cars. However, in the radio-telephone system, one antenna tower of 25 channels can be built in one large city. This means that the radio should be powerful enough to transmit waves over a hundreds of kilometers. It also meant that only few people can use this communication device because of the very limited channels. Now, cellular system was built. The city is divided into smaller cells and each cell site is considered as a base station where calls can be placed and received. Also the cell phones and base stations have low power transmitters and so do not reach much beyond the cell boundaries. Therefore, cell sites can transmit the same frequency at the same time as long as they are not adjacent. With this, more people can use cellular phones!

And I got something to add…since cell phones are low-power transmitters, small batteries can be used. This what makes cell phones very handy! Yehey!

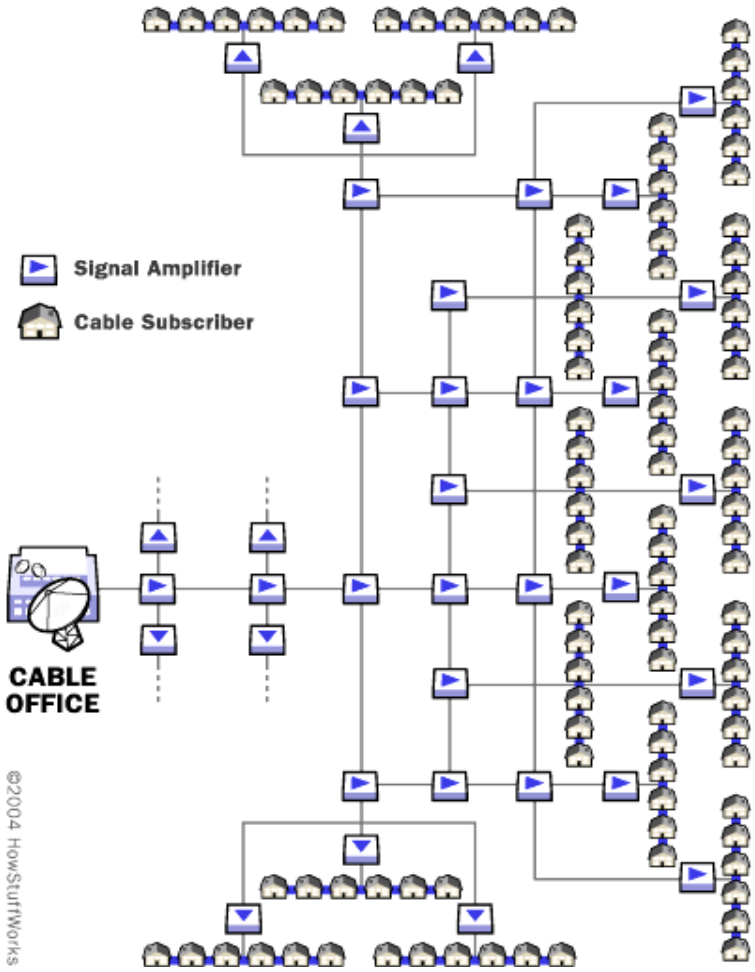
Did you know that…

According to one of the publications of Southeast Asian Press Alliance, the Philippines is now known as the text capital of the world. Over 100 million text messages are sent every day!

Further Improvements in Communication

Do you notice that a lot of people now resort to Cable TV for news, entertainment and educational programs? CATV or cable TV is now used because of its wide range of channels and clearer sound and picture. Moreover, some cable companies provide internet access to users. How does this amazing CATV work? In the cable system, signals are received through dish antennas and are delivered to subscribers through coaxial cables. The signal however gets weaker as it travels the cable so amplifiers are installed at strategic places along the cable to boost the strength of the signal. Recently, the bandwidths of cable systems are increased and so the number of channels has increased. Today, engineers are suggesting the use of fiber optics and lasers in cables as laser cables are more efficient in transmitting signals than coaxial cables. This will enable cable providers to lessen the amplifiers resulting to cost-effective system, cheaper subscription fees and better quality of pictures and sounds. Studies on other uses of fiber optics and layers are still ongoing. Digital systems are also looked into. Much is really yet to be discovered!

Fig. 13.
Cable TV System

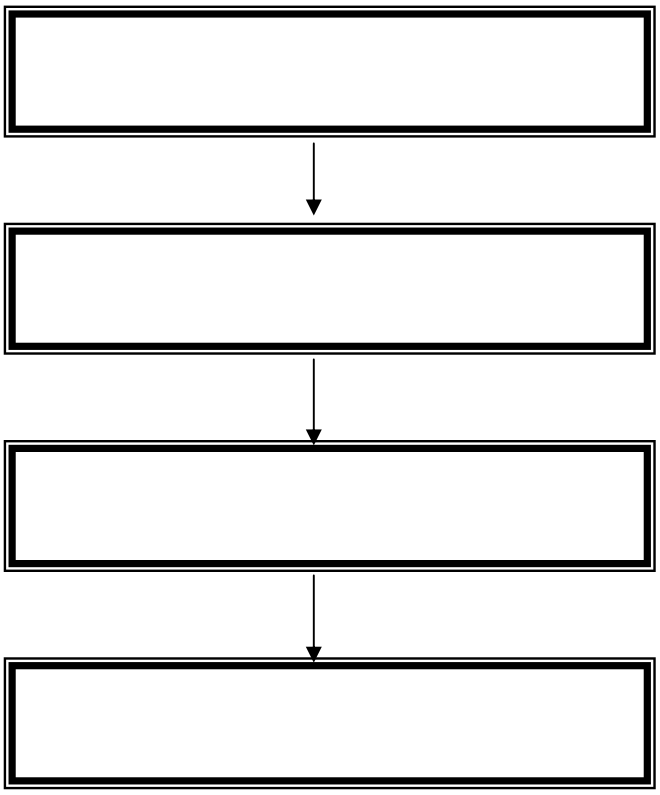


What you will do

Self-Test 2.1

History of Communication!

Using the flow chart on the next page, trace the development of communication from the time sending messages by electricity was devised to the present. You may add more boxes. Include other important details on the space at the right side.



Key to answers on page 28

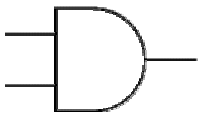
The Basics of Communication Devices

Sending information, messages or data can be done in two ways: (1) **through analog method and (2) through digital method**. Radio and phonographs transmit information using the analog method. Digital computers use the latter method.

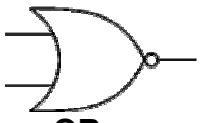
Let's discuss the analog method first. Analog devices send information by regulating electricity. The variable resistor is the main component of the circuit that does this by varying the current or voltage that runs through the circuit. The pattern of these variations is then interpreted or decoded and the message is understood. The AM and FM are analog methods of sending messages and information.

The digital method on the other hand, sends information through switching. Switching is another way of regulating electricity but with higher speed than analog method. Transistors and diodes act as switches (sometimes amplifiers).

Switching circuits that process data (in decision stage of electronic circuits) are called logic gates. Logic gates have three basic types: (1) AND gate; (2) OR gate and (3) NOT gate. Logic gates can be combined to form other logic gates.
The following are the logic gates traditional symbols:



AND



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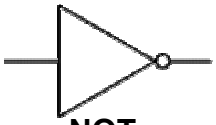
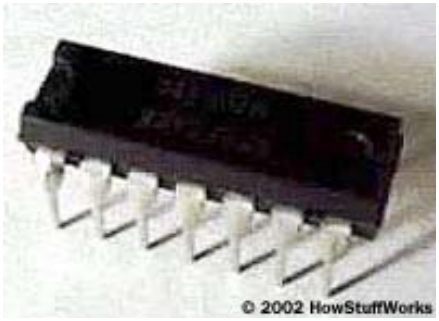


NOT



Electrical devices such as transistors and diodes can be combined in one silicon chip to form the integrated circuit. An integrated circuit can act as amplifier or a switch but operates at much higher speed. It is also cheap and very reliable. Modern computers use silicon chips for high speed processing of data.

What you will do

Self-Test 2.2 Journal Writing!

Based on what you have learned on the uses, applications and development of radio communication, discuss the possible effects of these on people's daily affairs.

_____

_____

_____

_____

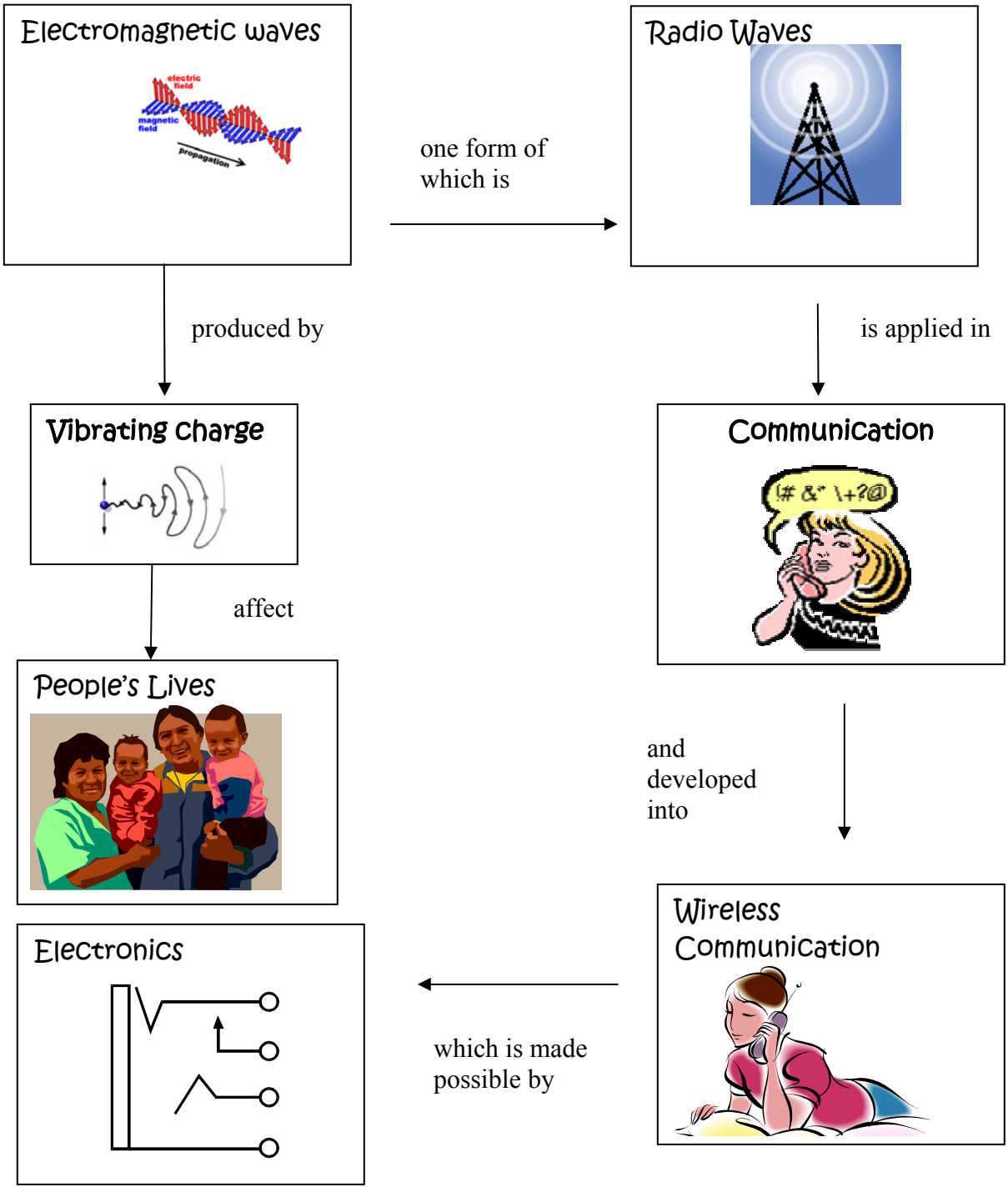
_____

_____

Key to answers on page 29

Let's summarize!

The following concept map synthesizes the lessons discussed:



Posttest

I. Direction: Encircle the letter of the best answer.

1. Electromagnetic waves are considered as _____
   A. electric waves
   B. longitudinal waves
   C. transverse waves
   D. mechanical waves

2. In the vacuum, the speed of the electromagnetic wave is _____
   A. zero
   B. always the same as the speed of light
   C. changing depending on the value of its wavelength
   D. none of the above

3. Which of the following forms of electromagnetic waves is used in cancer treatment?
   A. x-ray
   B. ultraviolet
   C. gamma ray
   D. microwave

4. Which wave has the shortest wavelength?
   A. x-ray
   B. ultraviolet
   C. gamma ray
   D. microwave

5. Which of the following energy transformations occur at the receiving station?
   A. Sound energy to electrical energy
   B. Electromagnetic energy to sound energy
   C. Electrical energy to electromagnetic energy
   D. Electromagnetic energy to electrical energy

II. Discussing and Explaining: Answer the following questions briefly. Write your answer on the space provided.

1. Discuss how transmission of radio wave occurs.

2. Discuss how television signal reaches homes.

3. List down further developments that scientists and engineers are studying for improvement of communication.

III. Appreciating

How has wireless technology improved people's way of life?

Key to answers on page 29

Key to Answers

Pretest

I. Multiple Choice

1. D
2. C
3. D
4. D
5. A

II. Discussing and Explaining

1. When the electromagnetic wave in the form of radio wave passes by a receiving antenna, energy is absorbed and current in the conductor induces a potential difference. This voltage is delivered to the receiver where it is amplified. This varying electric field produces changing magnetic field that vibrates the radio speakers.
2.
   A. telephone - easy distance communication
   B. television - fast access to news/programs
   C. cell phones - mobile communication
   D. satellites - faster communication around the world
   E. internet - fast access to all kinds of information
3. Distance communication has become possible through the *invention of telegraph*. From here, developments have arisen. *Telephone* was invented for easier communication and after which *radio communication* came.

III. Sequencing

1,2,3,4

Lesson 1

Activity 1.2

EM Wave	Frequency Range (hertz)	Wavelength Range (meters)
Radio Waves	$10^{2} – 10^{12}$	$10^{-4} -10^{6}$
Microwaves	10^{9}-10^{10}	10^{-1}-10^{-3}
Infrared	10^{11}-10^{14}	10^{-6}-10^{-3}
Visible Light	10^{14}-10^{15}	10^{-7}-10^{-3}
Ultraviolet	10^{15}-10^{17}	10^{-9}-10^{-7}
X-rays	10^{17}-10^{19}	10^{-12}-10^{-8}
Gamma rays	10^{18}-10^{25}	10^{-17}-10^{-11}

Self-Test 1.1

1. Electromagnetism principles are summarized in Faraday's Law and Oersted discovery. For electromagnetic waves to be produced, disturbance, which is the vibrating charge, must occur. When the charge is moved, the electric field around it is changed. In the Oersted's discovery: A changing electric field produces a magnetic field. A changing magnetic field is therefore produced around the vibrating charge. Furthermore, this changing magnetic field produces electric field as according to Faraday's Law.
2. Different forms of electromagnetic waves are used for different purposes, although some have common uses. For instance, X-rays, gamma rays and ultraviolet rays are used for medical purposes. Radio waves and microwaves are both used in wireless communication. In terms of properties, the different forms also have different frequency and hence different wavelengths. The gamma rays are high frequency waves and the radio waves are the low frequency waves.
3. Radio waves are widely used for wireless communication,

Lesson 2

Activity 2.1

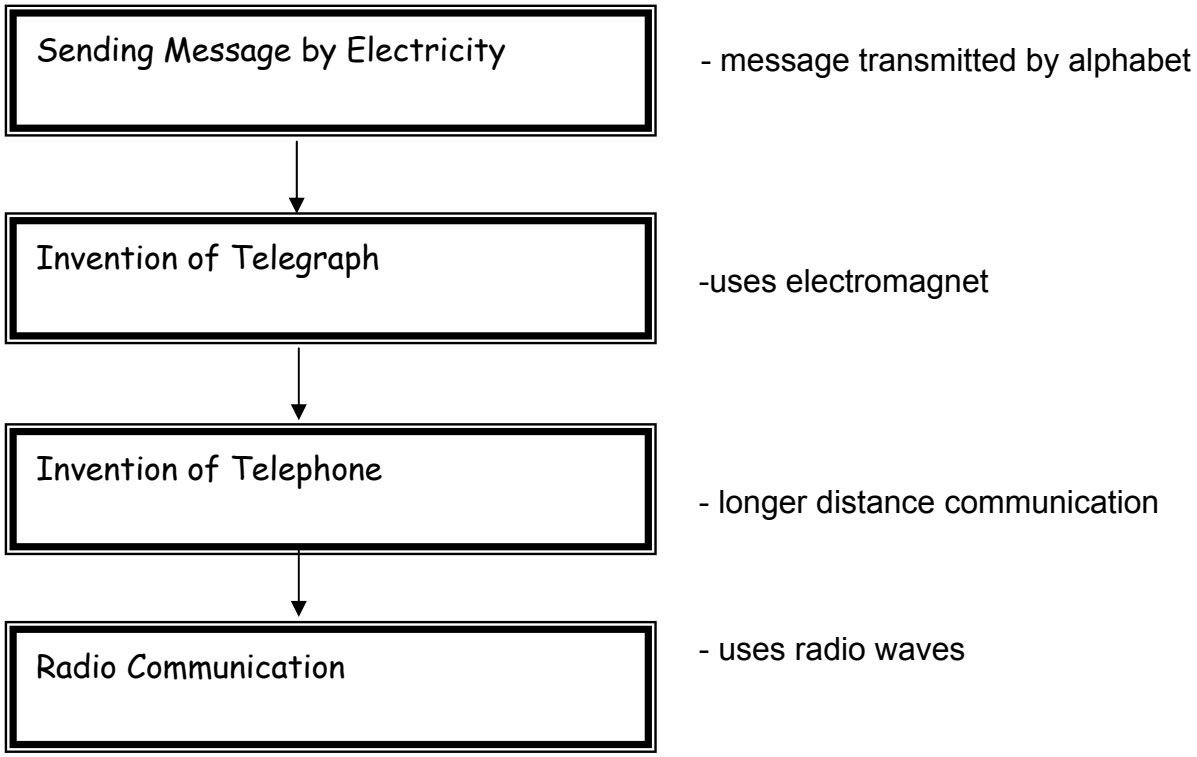
1. Rattling sounds are produced which indicates that radio waves are being transmitted and received by the AM radio's antenna.

Activity 2.2

Frequency Range and Uses of Broadcast Bands

Type of Broadcast Band	Frequency Range	Typical Uses
Very Low Frequency (VLF)	10kHz-30kHz	Long distance radio connections
Low Frequency (LF)	30KHz-300kHz	Broadcasting, maritime navigation, long distance radio connections
Medium Frequency (MF)	300kHz-3MHz	Broadcasting, marine communication, maritime navigation
High Frequency (HF)	3MHz-30MHz	Medium and Long distance communication
Very High Frequency (VHF)	30MHz-300Mhz	Television, FM, mobile communication
Ultra High Frequency	300MHz-3000MHz	Radio links, television radar, aerial navigation
Super High Frequency (SHF)	3000MHz-30000MHz	Radar, wave guide communication

Self-Test 2.1



Self Test 2.2 (Answers may vary but the following points/ideas should have been considered)

Effects of wireless communication to society depend on how it is used:

Responsible use of wireless communication devices leads to:

- Easy and faster access to relevant information
- Faster communication, which would result to efficient work and services
- More research and development

Irresponsible use of wireless communication leads to:

- Posting and use of invalidated and inaccurate facts and information
- More money spent
- Easy access to malicious statements and figures

Post-Test

I. Multiple Choice

1. C
2. B
3. C
4. C
5. D

II. Discussing and Explaining

1. Simple radio transmitters work on two basic processes: (1) transformation of sound energy to electrical energy; (2) transformation of electrical energy to electromagnetic energy. The first occurs in the microphone and oscillator circuit while the last occurs at the antenna.

2. There are many different ways for the TV to receive signals. The most common is the broadcast programming where signal is received through the antenna (e.g. analog TV). When one tunes into his favorite channel, his TV extracts the video signal and the sound signal of this particular frequency band.

3. Lasers and fiber optics are now being studied to improve wireless communication.

III. Appreciating (the following points should have been considered)

- Family bond is strengthened through faster and easy communication
- Awareness and involvement to societal issues and concerns through easy access to information, news and programs
- Learning is made fun and simple for young and adult through television.
- More efficient work and services
- More research and development

-End of Module-

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